DOCUMENT RESUME

ED 479 442 IR 022 119

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TITLE	Assessing the Usability of MOA Interface Designs.
PUB DATE	2002-10-00
NOTE	8p.; In: E-Learn 2002 World Conference on E-Learning in Corporate, Government, Healthcare, & Higher Education. Proceedings (7th, Montreal, Quebec, Canada, October 15-19, 2002); see IR 022 093.
AVAILABLE FROM	Association for the Advancement of Computing in Education (AACE), P.O. Box 3728, Norfolk, VA 23514. Tel: 757-623-7588; e-mail: info@aace.org; Web site: http://www.aace.org/DL/.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS
DESCRIPTORS	Computer Assisted Instruction; *Computer Interfaces; *Computer System Design; Educational Technology; Instructional Design; Instructional Effectiveness; *Instructional Materials; Multimedia Materials; Use Studies; User Satisfaction (Information)

ABSTRACT

This study evaluates the usability of the proposed MOA (mouse-over-abstract) interfaces that could be implemented in Web-based or stand-alone applications. The MOA designs provide users with an abstract that serves as context cues about the information presented in the linked page. The context cues are available in visual and/or audio formats. Evaluation of the MOA usability focuses on its affordances in efficiency, effectiveness, and user satisfaction. The proposed study aims to examine the influence of the MOA interfaces and presentation modality on program usability. The study also aims to evaluate the relationships among the three aspects of usability. Findings of the proposed study have implications in bridging the gap between research and practice. While results serve as empirically tested guidelines for interface designs applicable for computer-based learning programs, the application of study results also set examples for usable educational research. (Contains 31 references.) (Author)

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Assessing the Usability of MOA Interface Designs

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Abstract: This study evaluates the usability of the proposed MOA (mouse-over-abstract) interfaces that could be implemented in web-based or stand-alone applications. The MOA designs provide users with an abstract that serves as context cues about the information presented in the linked page. The context cues are available in visual and/or audio formats. Evaluation of the MOA usability focuses on its affordances in efficiency, effectiveness, and user satisfaction. The proposed study aims to examine the influence of the MOA interfaces and presentation modality on program usability. The study also aims to evaluate the relationships among the three aspects of usability. Findings of the proposed study have implications in bridging the gap between research and practice. While results serve as empirically tested guidelines for interface designs applicable for computer-based learning programs, the application of study results also set examples for usable educational research.

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Rationale

In the digital era, an information space contains more than text. The incorporation of the Internet and interactive multimedia have provided users with alternative ways of handling information. Hypertext structure, for example, allows the user to share the authorship of the intended reading. Consequently, there has been an ample amount of research conducted on user behavior in the electronic information space, and best practices have been suggested regarding information use within the digital medium. Studies that have contrasted reading on screen from reading printed matter (Dillon, 1992; Egan, Remde, Landauer, Lochbaum, & Gomez, 1989; Martin & Platt, 2001; Poynter Institute, 2000) support the notion that the electronic information space is more than just a variation of document media. Users actually develop ways to interact with the electronic information space that are substantially different from how they would interact with other media.

Traditional information space – such as books and journals – provides facilities such as tables of content, headings, and abstracts. This "meta-structure" serves to make both the organization and content of the material explicit to the user. Given that such improvements in the design usability of printed material has been an evolutionary process that has lasted at least 500 years (Febvre & Martin, 1976), it is reasonable to expect that it will also take some time before we come up with the best meta-structure for information retrieval in the electronic space. As a result, the usability of the electronic information space is an issue worth addressing.

Conceptual Framework

Usability

Although "usability" is a term that has been widely discussed, there is a lack of consensus on its definition (Jordan, 1998; Marchionini & Crane, 1994). Numerous authors have adopted the definition of the ISO (1998), by which effectiveness, efficiency, and user satisfaction are the three aspects of usability.

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Evaluation of the general concept of usability is then made possible by concretely defining the parameters of the three terms (Frøkjær, Hertzum & Hornbæk, 2001; Nielsen & Levy, 1994).

Effectiveness is usually measured by the extent to which an intended task is successfully completed. *Efficiency* refers to the amount of effort it takes to complete the task and may be measured according to indicators that include deviations from the correct path, error rate, the amount of time spent, and mental workload. *User satisfaction*, the last component of this product usability scheme, refers to how comfortable users are using a certain product to achieve a specific goal; user satisfaction is usually measured using the method of self-report. While effectiveness and efficiency yield measures of objective performance, user satisfaction provides insight about subjective preferences of application users.

It has been suggested that claims of usability should take into consideration all three aspects of usability as well as their interrelationships (Frøkjær, Hertzum & Hornbæk, 2000; Nielsen & Levy, 1994). For instance, because it is difficult to measure effectiveness as a component of usability, many studies have rested on the assumption that effectiveness equals efficiency of user performance. However, caution should be applied to conclusions based on such assumptions, because it remains to be proven that effectiveness is reducible to efficiency. In essence, when examining product usability, one must recognize the interplay among the defining properties.

Web usability and information seeking

The evaluation of Web usability can not be conducted without the context of information-seeking behavior. This is because the evaluation criteria of Web usability – such as effectiveness, efficiency, and user satisfaction – are essentially the perceived outcome of information-seeking activities. According to Marchionini (1995), how someone interacts with the information space is determined by the given individual's "personal information infrastructure." This personal information infrastructure is a constellation of interconnected mental models.

The concept of mental models (Johnson-Laird, 1983) is one of the theories proposed by cognitive psychologists to explain human cognitive activities. The mental model theory proposes that individuals react to situations or make predictions about circumstances in reference to their pre-existing mental models. In other words, the mental models serve as the individuals' inner template of the real world. In the present case, a mental model about the content of a Web page will allow the reader to make predictions about the material; thus, it may facilitate – or impede – the reader's comprehension of the information being presented.

Previous research findings support the notion that mental models play an essential role in information-seeking behavior (e.g., Borgman, 1986; Dimitroff, 1992; Liebscher & Marchionini, 1988; Kerr, 1990; Webb & Kramer, 1990). In fact, information seeking may be viewed as the process humans undertake specifically in order to modify their mental models – by changing the state of their knowledge so as to better resolve internal contradictions. It is assumed that, when an information problem is detected, information-seeking behavior is initiated in order to repair the perceived deficiency.

Web-usability problems

Although there has been much discussion about Web-usability problems over the years, there is still a lack of consensus on what the core difficulty is (Marchionini, 1995; Toms, 2000). It has been suggested that some problems might be due to the fact that certain information used to navigate printed text is not available in electronic text environments. Two of the oft-cited Web-usability problems are *cognitive overload* and *disorientation*.

The term cognitive overload or information overload is usually used to describe a state wherein the received information becomes a hindrance rather than a help. Even though cognitive overload is not a new concept, it was not until the 1990s that this phenomenon started to be perceived as a major problem associated with the new technological advances (Bawden, Holtham & Courtney, 1999).

Disorientation – or "getting lost in cyberspace" – is another negative consequence of information seeking in the electronic information space. Conklin (1987) defined disorientation as the users' tendency "to

lose their direction and sense of location" in a non-linear information environment. It has been suggested that such phenomena might be due to factors such as unfamiliarity with the document structure (Foss, 1989) and lack of contextual cues (Park & Kim, 2000; Soderston, 1986).

Over the years, various types of interface designs have been proposed to tackle Web usability problems (e.g., Florance, 1992; Foss, 1989; Furnas, 1986; Geesei & Martin, 1989; Hammond & Allinson, 1987; Kerr, 1989; Park & Kim, 2000). Most of these meta-structural designs aim to help users have a sense of what kind of information is to be found, where they are in the system, and how to move around the information space without incurring cognitive overload (Toms, 2000). Essentially, a lot of these designs aim to deal with issues such as cognitive overload and disorientation by providing users with *context information*.

Context information is here defined as the explanation of the user's current situation in the Web environment. For instance, Park and Kim (2000) conducted a study to examine the effectiveness of contextual navigation aids in Web browsing activities. It was found that participants preferred the Web system with context information. Provision of context information also seemed to increase the efficiency of users' information-seeking activities. Over the years, various types of interfaces have been proposed to facilitate users' information-seeking behavior in the electronic information space (e.g., Conklin & Begeman, 1989; Egan, Remde, Landauer, Lochbaum & Gomez, 1989; Florance, 1992; Foss, 1989; Furnas, 1986; Geesei & Martin, 1989; Hammond & Allinson, 1987; Nielsen, 1990; Webb & Kramer, 1990). Most of these designs present information through visual rather than audio channels.

In response, the current study aims to propose an interface design called MOA, an acronym for Mouse-Over-Abstract, that provides Web users with context cues in visual *and/or* audio formats. The context cues appear when users place the mouse over a hyperlink and they are abstracts of the information presented on the linked page. It is anticipated that such contextual cues will serve as landmarks in the hypertext environment to ameliorate the issue of disorientation and, therefore, minimize the amount of cognitive load attributable to navigation.

Following are some questions concerning the evaluation of the proposed design.

1. Do participants perform better with, and show a preference for, MOA interfaces as opposed to an interface that does not have this feature?
2. Do different modalities (e.g., text, audio) of MOA interfaces result in differential degrees of participant performance and/or preference?
3. What are the relationships among the three aspects of usability: effectiveness, efficiency, and satisfaction?

Methodology

Participants

Eighty participants will be recruited from colleges and universities in the New York metropolitan area. There will be a twenty-dollar compensation for their one-and-a-half-hour participation. Educational level and experience with computers and computer-mediated information systems have been found to be confounding variables of usability. As a result, eligible participants will need to have at least a college-level education and have at least three years of experience with computer-based information systems.

Materials

The domain contents in the current study will include both natural science and social science topics. Content materials will be provided and edited by experts in the given fields. Content experts were given three guidelines to take into account when choosing their topics. First, the difficulty level of the domain content should be comprehensible for individuals with a college-level education. Second, contents should not be easily guessable, and comprehension of the given content should require the user's efforts and cognitive processing. Third, the topic should be interesting to the general public. Based on these guidelines, two topics were chosen.

The natural science topic addresses the specific question: "Why does the moon have phases?" The social science topic concerns the functions and histories of Institutional Review Board.

Two Web applications will be generated based on the provided contents. Subject materials will be divided into subsections and presented in HTML format. JavaScript will be used to develop the interface needed to present the visual and audio context cues. Basic interface design of the Web pages will adhere to general guidelines suggested by Web usability experts (e.g., Nielsen, 2000).

Experimental treatments

The current study involves four kinds of interfaces including one control interface and three experimental interfaces. Participants in the experimental groups will be presented with the MOA interfaces that provide context cues when they put the mouse on a hyperlink. One MOA interface provides context information in text format, another in audio, and the other contains information in both modalities. No such add-on mechanism is available in the interface for the control group.

Measures

Demographic information. Participants will be required to provide background information on a demographic sheet. These questions include gender, age, level of education, college major, number of computer-usage hours per week, years of experience with computers, years of experience with the Internet, and the computer platform (e.g., PC, Mac) with which they are most familiar.

Efficiency. A system log will be used to record the time participants spend and the links they click on the Websites. Participants will also complete a set of questions, which rates their subjective perception about the mental load during their interaction with the interfaces. The mental load ratings are based on a 7 point Likert scale, with 1 indicating very easy and 7 indicating very difficult. Previous research has indicated the subjective measure easy to administer and as reliable as objective methods (e.g., Mayer & Chandler, 2001).

Effectiveness. After the interaction with the experimental system, the users will be given a set of multiple-choice questions to assess their recollection and comprehension of the domain contents.

User satisfaction. User satisfaction will be evaluated using an abbreviated version of the Shneiderman's Questionnaire for User Interaction Satisfaction. There will be a set of eight Likert scale items included in the questionnaire (Toms, 2000).

Procedure

The experiment will be conducted in the computer lab of the Academic Computing Services located at Teachers College and supervised by two experiment administrators. Equipment required to run the study includes twenty PC laptops with external mouse attached. The applications will be loaded on the hard drives of these laptops before the experiments. Four group experiments are expected be conducted with twenty subjects within each section. Individual sections may also be considered.

At the beginning of the experiment, the participants will be requested to fill out a demographic sheet. After the completed demographic sheets are collected, the participants will be informed that the entire experiment will be divided into two forty-minute sessions with a five-minute break between sessions. Participants will be requested to browse through the provided Websites.

Participants will be randomly assigned to one of the four groups: a) the control group will be presented with the control interface which contains no add-on features; b) the visual group will be provided with the text-based MOA interface; c) the audio group will receive an audio-supplemented MOA interface; and d) the hybrid group will have a MOA interface providing context cues in both visual and audio format. Within each of the four sub-groups, half of the participants will be given the natural science topic first and half the social science topic. Efforts will be made to ensure equal gender distribution among different treatment groups.

After the browsing session, participants will be asked to respond to the measures mentioned above in order to assess the efficiency, effectiveness and user satisfaction properties of the interfaces. Five minutes will be allocated for the mental load ratings, ten minutes for the recollection and comprehension task, and five minutes for user satisfaction questions. At the end of the first session, the participants will be provided with a five-minute break. The break aims to alleviate the possible impact of fatigue on user performance. Upon their return, the same procedure will take place again. In the second session, participants who were provided with the natural science topic in the first session will be given the social science topic, and vice versa.

Anticipated Results

Methods of analysis

Efficiency. Three measures will be implemented to determine the concept of efficiency. First, efficiency (E1) will be measured based on the ratio of the time a participant devoted to reading (Tr), to the total amount of time spent (Tt): E1= Tr / Tt. Second, efficiency (E2) will also be measured based on the number of links required for a perfect path (Cp), over the number of links the user clicked through to complete the task (Cn): E2 = Cp / Cn. For both E1 and E2, a higher degree of efficiency is indicated as a value of E1 or E2 approximating 1, a low degree of efficiency by values approaching 0. These two measures both rest on the assumption that excessive clicking behavior may be a sign of *disorientation*. The total value of the individual mental rating items will be tabulated and serve as a third measure for efficiency. Because an efficient interface should require participants less cognitive load, higher mental load scores represents lower degree of efficiency and vice versa.

Effectiveness. The degree of comprehension (Effectiveness) will be assessed based on the number of correct items (Ic), over the total number of items (It): Effectiveness = Ic / It. A higher degree of effectiveness is indicated as a value of Rec approximating 1, a lower by values approaching 0.

User satisfaction. Summing up users' responses to the eight-item Likert scale questionnaire will generate a total score for user satisfaction. The final score will be used as the final indicator of user satisfaction.

Results

The two-by-two factorial design of the current study results in four groups of twenty participants each, as indicated in the matrix shown in Table 1.

	No audio cues	**Audio cues**
No visual cues	Group 1 (Control Group)	Group 2
Visual cues	Group 3	Group 4

Table 1: Mapping the treatment received by the 4 groups.

Efficiency. Efficiency is defined both as the amount of time it takes to find the topic of interest and the amount of cognitive load it requires for participants to process information. Because the MOA interfaces will provide users with a general overview of the linked page, such provision should help users find information of interest efficiently. As a result, it is expected that participants provided with the MOA Interfaces (Groups 2, 3 and 4) will spend more time reading and less time browsing than the comparison group (Group 1).

Effectiveness. Effectiveness is indicated by the participant's performance in recollection and comprehension. Fundamental to the interface design are the assumptions that: 1) the provision of an abstract will provide the users with a mental model about the content in the linked page; 2) elements in the abstract will prime and sensitize the users to the essential information to look for; and 3) information contained in the MOA interfaces could serve as a landmark in the information space. As a result, it is expected that participants provided with the MOA interfaces (Groups 2, 3 and 4) will perform better than the comparison group (Group 1). Moreover, among the three MOA interfaces, the hybrid MOA interface is expected to show the highest degree of effectiveness because two channels of the same message should have a reinforcing effect.

User satisfaction. User satisfaction is evaluated based on participants' self-report. Although the MOA interfaces will provide users with a facilitating mechanism to achieve the information-seeking goal, users may not be familiar with the given interface design. Therefore, it is expected that participants without MOA interfaces (Group 1) will provide higher scores on the measure of user satisfaction than the comparison groups (Groups 2, 3 and 4).

Interactions between usability components. In the current study, a negative correlation is expected between the measure of effectiveness and user satisfaction. This is because, while the MOA interfaces facilitate learning and comprehension, the unfamiliarity with the interface results in lower degree of user satisfaction.

More importantly, the current study will also find the redundancy principle of multimodality (Mayer, 2002) to be inapplicable. The redundancy principle argues that the incorporation of multiple modalities might have detrimental rather than beneficial impacts, when it is the same information being presented. It should be noted that most of the supporting research for the redundancy principle present contents in multiple modalities. Yet, content provided in the MOA interfaces are only to prime users with concepts to be covered; detailed information are provided in the same format across all four conditions in the current study.

Implications

One goal of the proposed study is to bridge the gaps between practices and research. While most recommended Web design guidelines are not empirically based, there has been lament about the lack of "usability" in educational research. The proposed study will set forth an example to address the given issues.

Findings also can provide evidenced guidelines for technology-based projects, such as distance-learning education and online libraries, concerning how multimodal presentations should be deployed and how cost-beneficial such practices could be. Moreover, results of the proposed project will also point to the fact that, when evaluating technology projects, it will not be sufficient to assess user satisfaction because usability is a multifaceted concept.

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